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TECHNOLOGY UTILIZATION

COMPUTER PROGRAMS: ELECTRONIC CIRCUIT DESIGN CRITERIA

A COMPILATION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Foreword

The National Aeronautics and Space Administration has established a Technology Utilization Program for the dissemination of information on technological developments which have potential utility outside the aerospace community. By encouraging multiple application of the results of its research and development, NASA earns for the public an increased return on the investment in aerospace research and development programs.

This publication is part of a series intended to provide such technical information. The 21 items reported herein describe computer programs that are applicable to electronic circuit design procedures.

Additional information on individual items can be requested by circling the appropriate number on the Reader Service Card included in this compilation; or from: COSMIC, 112 Barrow Hall, University of Georgia, Athens, Georgia 30601.

We appreciate comment by readers and welcome hearing about the relevance and utility of the information in this compilation.

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Technology Utilization Office
National Aeronautics and Space Administration

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Computer Programs: Electronic Circuit Design Criteria

ON-AXIS POWER DENSITY IN THE FRESNEL AND FRAUNHOFER REGIONS OF LARGE-APERTURE RECTANGULAR AND CIRCULAR ANTENNAS

Development of radio frequency transmitting systems with high power transmitting tubes and high gain antennas has increased the possibility of biological injury to personnel working in the vicinity of these emitters. The Bureau of Medicine and Surgery has established ten milliwatts per square centimeter (10 mW/cm^2) as the safe continuous exposure level. The purpose of these programs is to provide design engineers with power density data which may be used to predict radio frequency radiation hazard (RAD HAZ) areas.

Given the transmitter power, the far field antenna gain, the antenna dimensions, and the far field beam width, Program DOD-00013 calculates and prints out the near field gain, the near field beam width, and the on-axis power density in the Fresnel and Fraunhofer regions of large aperture rectangular antennas.

Program DOD-00014 determines the aperture distribution from the antenna parameters and calculates the on-axis power density in the Fresnel and Fraunhofer regions of large aperture circular antennas.

The program reads and punches out the equipment nomenclature and the equipment characteristics, including the diameter of the antenna, frequency, far field antenna gain, and beam width. The far field distance is calculated. The distance at which the power density is calculated is set at 10 feet initially. The defocusing factor is calculated. The power density in the Fresnel region and the near field antenna gain and beam width are then calculated and punched out. The distance is then increased by an increment, and the program goes back to calculate the new power density. This iteration loop continues until the distance reaches 15,000 feet. For computing the power density, the defocusing factor is set to 1 when the distance exceeds the far field distance.

Language: FORTRAN IV
Machine Requirements: IBM-7090

Source: Naval Ship Engineering Center
(DOD-00013, 00014)

Circle 1 on Reader Service Card.

FARADAY ROTATION COMPUTER PROGRAM

This program computes the Faraday rotation of a signal passing through a plasma in the presence of a static magnetic field. An "exact" solution (the usual quasi-longitudinal approximation for the magnetic field is not used) provides the Faraday rotation for uniform stratified sections. The signal polarization and ellipticity are computed for each step.

Language: FORTRAN V (60%), DATA (40%)
Machine Requirements: UNIVAC-1108, EXEC-8
Source: Jet Propulsion Laboratory
(NPO-11232)

Circle 2 on Reader Service Card.

LOW-NOISE RECEIVING SYSTEM, NOISE TEMPERATURE CALIBRATIONS

This is a program to calculate the system noise temperature of low-noise receiving systems by the "Y" factor method. In this method the power ratio at the system output is measured when the system input is connected alternatively between the antenna and an ambient termination. A statistical least squares technique is used to compute the best estimate of the power ratio from a series of measurements. The system temperature is defined by the ambient termination temperature, the receiver noise temperature, and the power ratio.

The program computes and tabulates the statistical measurement dispersion errors and various system bias errors. In addition, various related system parameters of interest, such as reflectometer match measurements, are tabulated.

Language: FORTRAN IV
Machine Requirements: IBM-7094/7044 DCS
Source: Jet Propulsion Laboratory
(NPO-10612)

Circle 3 on Reader Service Card.

CALIBRATION OF MICROWAVE, THERMAL NOISE STANDARDS

Calibrated microwave, thermal noise standards usually consist of a matched element which is thermally isolated by a transmission line. This program calibrates these noise standards, accounting for arbitrary losses and temperature distributions along the transmission line. An iterative computing technique is used to transfer the source termination temperature (T) at (X=0, i=1) to the output of the transmission line at (X=ℓ, i=n). The transmission line loss distribution must first be determined by measuring the total loss ($\overline{\overline{L}}_i$) in db at various temperatures ($\overline{T}_i$). A curve fit is determined from:

$$\overline{\overline{L}}_i\text{, db} = A_1 + A_2\overline{T}_i + A_3\overline{T}_i^2 + \ldots$$

and the constants A_1, A_2, ... (used as input data). The operational temperature distribution along the transmission line entered as a table, X_i versus T_i, completes the required input data.

Language: FORTRAN IV
Machine Requirements: IBM-7094/7044 DCS
Source: Jet Propulsion Laboratory
(NPO-10610)

Circle 4 on Reader Service Card.

COUPLED CAVITY MASER NOISE TEMPERATURE

This program has been designed for the analysis of the equivalent noise temperature of cascaded negative-resistance maser amplifiers separated by isolators. The principal noise contributions in the amplifying section are (1) amplified noise from the preceding stages, (2) cavity losses and internal spin temperature contributions, and (3) noise from the output, including thermal noise and transmitted noise produced by the finite reverse attentuation of isolators.

The effective noise temperature is determined by calculating the noise contributions of the various circuit elements, accounting for their gains, summing, and referring the net contributions to the amplifier input. The output of the program includes curves for various gain, loss, reverse isolation, and maser inversion ratios.

Language: FORTRAN II
Machine Requirements: IBM-1620

Source: Jet Propulsion Laboratory
(NPO-10590)

Circle 5 on Reader Service Card.

NETWORK PATH PROGRAM

Network Path is a FORTRAN IV computer program to determine the Nth best minimum or maximum path in a network. The program was developed from a paper by W. Hoffman and R. Pavley, *A Method for the Solution of the Nth Best Path Problem.* The minimum tree concept as developed by E. F. Morre and G. B. Dantzig is employed to compute the best path. The minimum tree is then superimposed upon the network to determine the Nth best path, using a theorem. Any path P from O to D, which is not minimal, is a deviation from a path Q from O to D such that V(Q) < V(P). If P is minimal, then either P is unique or P is a deviation from another minimal path.

The method relative to computer application considers first finding all the paths of minimal value, i.e., Φ_1 is computed. Next a calculation is made of all deviations from the paths in Φ_1 and they are arranged in numerical order according to the path value which allows determination of Φ_2. All deviations from the paths in Φ_2 are then computed, ordered, and merged with non-minimal deviations from paths in Φ_1, thus determining Φ_3, etc. Only the Nth best path values are stored at any stage of the computation; therefore, for large networks, the required storage is essentially that which is needed to store the network.

This program is written to handle up to 500 nodes, and the branch links cannot exceed 5000.

Language: FORTRAN H
Machine Requirements: IBM-360/65

Source: Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-18691)

Circle 6 on Reader Service Card.

SYSTEM ATTRIBUTES PROGRAM

This program provides a means of single channel verification for system checkout of amplifiers and frequency-to-voltage converters on a group basis. The program calculates the average and precision of analog inputs on a single channel basis. It calculates and stores an average count value for each selected channel based on 64 samples. This average value (base number) is compared to each data sample of the actual test. The sum of the differences and the sum of the squares of the differences are compared and stored as double precision words. Provisions are included to delete bad channels, vary the sample size, and select the format of the output.

Language: Assembly
Machine Requirements: DDP-116
Source: Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-18639)

Circle 7 on Reader Service Card.

RESISTOR CALIBRATION PROGRAM

This program computes the resistance, average resistance, and precision of a stock resistor by comparing it to a standard resistor.

The input consists of the ohms and serial number of both the standard resistor and the tested resistor, a code number for the principal standard, and the resistance of the standard. This information is followed by the voltage drops of the comparison standard and the test resistor.

Language: FORTRAN H
Machine Requirements: IBM-360/Release 11
Source: Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-18412)

Circle 8 on Reader Service Card.

PROGRAM FOR CALIBRATION OF STANDARD RESISTORS

This program produces, for a standard resistor, a table of temperature vs resistance values from the following formula:

$$R_T = R_{25}\ [1.0 - A\,(T - 25) + B\,(T - 25)^2]$$

where

R_T = Resistance, in ohms, at the given temperature
T = Temperature in °C
R_{25} = Resistance, in ohms, at 25° C (input)
A = Alpha coefficient in parts per million (input)
B = Beta coefficient in parts per million (input)

The table values are computed for a fixed temperature range of from 15° C to 35° C, in increments of 0.05° C.

Language: FORTRAN H
Machine Requirements: IBM-360, Version 11
Source: Rockwell International Corp.
under contract to
Marshall Space Flight Center
(MFS-18140)

Circle 9 on Reader Service Card.

PASSIVE NETWORK PROGRAM

This computer program calculates the input impedance and transfer function of an electrical network composed of such components as capacitors, resistors, and inductors. The poles and zeros of the input impedance and network transfer function are computed. The network is described by the user with the aid of a problem oriented input data sheet. The input impedance and transfer function are expressed as ratios of real polynomials P(s)/Q(s). The roots of P(s) and Q(s) are also expressed.

This program can be used for any R-L-C filter network with a maximum of 40 components and twenty current loops.

Language: FORTRAN IV
Machine Requirements: IBM-360

Source: The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-15142)

Circle 10 on Reader Service Card.

MINIMUM PHASE PROGRAM

In designing control systems, it is necessary to design a passive electrical network which satisfies specified gain and phase characteristics. It is assumed that a passive network can be constructed whose corresponding transfer function reflects stability of the network. If the minimum phase lag associated with a specified gain characteristic is less than a desired phase lag, then an actual electrical network can be constructed which will satisfy both gain and phase characteristics set forth by the engineer. The Minimum Phase Program determines the minimum phase lag of passive electrical networks reflecting the degree of stability of the transfer functions basically established by the gain characteristics determined by the engineer in the program input. The phase lag is determined in the program as a function of frequency for a specified gain characteristic.

To describe gain characteristics, the program user inputs a tabular array of gain versus frequency and two slopes. The slopes are used to define the gain curve for frequencies before and after the frequencies in the tabular defined region. The slopes are inputs. The integration technique employed is the trapezoidal method, and the integration can be expressed as a function of frequency. The limits of integration are computed from a fraction and multiple by each c^{th} frequency value. The fraction and multiple integration limits are user input. The accuracy of the technique depends primarily on the increment used to form the base of each trapezoid. The user can divide the curve into three regions, each with its own frequency increment. The frequency increments are also user input.

Language: FORTRAN H
Machine Requirements: IBM-360, Release 11

Source: The Boeing Company
under contract to
Marshall Space Flight Center
(MFS-15045)

Circle 11 on Reader Service Card.

ELECTRONIC CIRCUIT ANALYSIS PROGRAM (ECAP–AC)

This is a recent and different machine version of the IBM Electronic Circuit Analysis Program (known as ECAP), an integrated system of programs designed to aid the electrical engineer in the design and analysis of electronic circuits. This system of programs can produce DC, AC, and/or transient analyses of electrical networks from a description of the connections of the network (the circuit topology), a list of corresponding circuit element values, a selection of the type of analysis desired, a description of the circuit excitation, and a list of the outputs desired.

ECAP recognizes a set of standard electrical circuit elements. Any electrical network that can be constructed from any or all of the different elements in the set can be analyzed by ECAP. There is almost no limit to the number of ways that the circuit elements can be arranged in the network. The set of standard circuit elements does not include electronic components, but in many cases, these components are easily simulated by means of equivalent circuits constructed of standard elements. A number of examples are included in this manual that involve the use of equivalent circuits.

ECAP can handle electrical networks that contain as many as 20 nodes (not including ground nodes) and 60 branches.

ECAP allows the circuit designer to economically and efficiently determine the performance of a circuit during the various stages of its design, by using a computer rather than a "breadboard." In this way, the designer can rapidly determine the variations in circuit response that correspond to changes in circuit parameters. Studies can be made of circuits that contain costly components that may be difficult to obtain. Destructive excitation can be applied to the circuit with no fear of destroying expensive electronic circuit elements. Worst case combinations, which are hard, or practically impossible, to realize in the laboratory, can be examined. Measurements that may be difficult to make, and time consuming to instrument, can be made quite simply on the computer. Circuit connections can be changed rapidly. In many cases, ECAP can leave the designer with a clearer insight into the operation of the circuit than could be obtained with a breadboard study, and often at considerably less cost.

Language: FORTRAN IV
Machine Requirements: CDC-6600

Source: General Dynamics Corp.
under contract to
Lewis Research Center
(LEW-10667)

Circle 12 on Reader Service Card.

REALIZATION PROGRAM

This program is used to design frequency selective networks when the network configurations or topology are given. The element values are perturbed until the final design (if possible) is achieved. The program specifies the final design by prescribing element values and/or a network function T(S).

It is assumed that the approximation problem has been solved and that the coefficients of the desired network functions are known.

The principal features of the program are its abilities to accept arbitrary topologies, to "grow" new elements, and to converge rapidly.

It is possible to generate filters with prescribed loss from lossless filters, or to design bandpass amplifiers to accommodate transistors with prescribed small signal equivalent circuits. Also the frequency characteristics of networks can be altered by adjusting certain elements. For example, passive or

active, linear phase filters can be transformed from a design originally having a Tchebysheff amplitude response.

Language: FORTRAN IV
Machine Requirements: IBM-7090 or CDC-6400

Source: General Dynamics Corp.
under contract to
Lewis Research Center
(LEW-10664)

Circle 13 on Reader Service Card.

LINEAR, ELECTRONIC NETWORK ANALYSIS PROGRAM

This program may be used to determine the Laplace transform of linear electronic networks. It can also be used for finding the corresponding poles and zeros as well as the frequency and/or time domain response of a network.

For input, the program requires a list of elements (described by their terminal node numbers, element types, and element values) and functions (driving point impedance, voltage transfer function, etc.). The program then calculates the coefficients of the required network function, the poles and zeros, frequency response, and transient response to an arbitrary input.

Allowed element types are resistors, capacitors, inductors, non-ideal transformers, and voltage-controlled current sources in arbitrary configuration. Network size is limited to 12-15 nodes, 25-30 elements.

Language: FORTRAN IV
Machine Requirements: CDC-6400 or IBM-7094

Source: General Dynamics Corp.
under contract to
Lewis Research Center
(LEW-10613)

Circle 14 on Reader Service Card.

RESISTANCE THERMOMETER CALLENDAR EQUATIONS

This program computes resistance values over a specified temperature range for a resistance thermometer, using the Callendar equation. Input consists of: the thermometer's resistance at 100° C and 0° C, the minimum and maximum temperatures of the temperature range in either degrees Centigrade or Fahrenheit, the temperature increment at which to compute resistance values, and two equation constants. If the requester desires not to input the thermometer's resistance at 100° C, an option is available to input a third equation constant. Output contains a table of temperature values (degrees C or F) and resistance readings over the temperature range.

Language: FORTRAN IV
Machine Requirements: GE-635

Source: Kennedy Space Center
(KSC-10422)

Circle 15 on Reader Service Card.

SIMULATION AND EVALUATION OF A CONVOLUTIONAL CODED PCM SYSTEM WITH SEQUENTIAL DECODING

This program simulates and statistically evaluates the performance of a convolutional coded PCM communications system with sequential decoding. The communications channel is assumed to be perturbed by white, additive gaussian noise. Each binary symbol correlation received is A to D converted to, at most, sixteen levels and stored in an array. Each array is then sequentially decoded. Up to 500 arrays or data frames may be decoded per computer run, and overflow and error rate statistics are then found and printed out.

The main program reads in system parameters, calculates parameters needed to encode and decode, prints out system parameters, controls number of frames to be processed, serves as a calling program for subroutines (and initializes subroutine variables) needed for encoding and decoding, and calculates and prints out statistics for total number of frames processed.

Language: FORTRAN IV
Machine Requirements: IBM-7094

Source: Goddard Space Flight Center
(GSC-10653)

Circle 16 on Reader Service Card.

COMPUTER PROGRAM TO DETERMINE THE EFFECTS OF RF FILTER SECOND- AND THIRD-ORDER PHASE ERRORS AND NON-LINEAR AMPLITUDE RESPONSES FOR A FREQUENCY-DIVISION-MULTIPLEX SYSTEM

A frequency-division-multiplex signal, when passed through a circuit consisting of an fm modulator, rf filter, discriminator (ideal), and band filters, or a non-linear amplifier, has distortion elements introduced. The circuit containing the rf filter introduces phase distortion and the non-linear amplifier introduces amplitude distortion. In order to evaluate these circuits without the necessity of actually constructing them and in order to evaluate the effects of varying signal bandwidths, spacing, and modulation, this computer program determines the distortion introduced by these circuits into the signal. Input data consists of the upper and lower cut-off frequencies and the peak deviation of the modulation for each of up to ten bands; the coefficients of each of up to four terms in the numerator and the denominator of the transfer function of the lowpass equivalent of the rf bandpass filter; the center frequency and the one-sided bandwidth of the rf filter; and the coefficients of up to three terms in the transfer function of the non-linear amplifier.

Language: FORTRAN II
Machine Requirements: RCA-601

Source: RCA Corp.
under contract to
Goddard Space Flight Center
(GSC-10586)

Circle 17 on Reader Service Card.

COMPUTER PROGRAM FOR THE SIMULATION OF A MULTIPLEXER/ DEMULTIPLEXER SYSTEM FOR NON-RETURN-TO-ZERO OR BIPHASE DATA TRANSMISSION

This program determines the effect on a signal of a simulated multiplexer/demultiplexer system consisting of a low-pass filter, a modulator, a bandpass filter for the multiplexer, and a bandpass filter for the demultiplexer. The program accepts as input an arbitrary non-return-to-zero or biphase data signal, the characteristics of the four filters, the modulating and demodulating frequency, and a phase offset of the demodulating frequency from the modulating frequency. The output from the program consists of a printout of the amplitude and phase of each of the harmonics of the simulated signal at the output of the system, punched cards and a printout of the amplitude values of the signal waveform as a function of time, and a printout of the integrals of the fifth to thirtieth output signal pulses.

Language: FORTRAN II
Machine Requirements: RCA-601

Source: RCA Corp.
under contract to
Goddard Space Flight Center
(GSC-10583)

Circle 18 on Reader Service Card.

ELECTRIC POWER ANALYSIS AND LIST OF POWER CONSUMING EQUIPMENT FOR SHIPS

This program generates listings of the ships' electric power consuming equipment and computes electric loads required for a power analysis. The program uses manually generated data and data retrieved from a library of naval ship auxiliary power consuming equipment. For given quantities and functional load factors, the program produces a line by line listing of all power consuming equipment and their electrical loads for various ship operating conditions (at anchor, cruising, battle, etc.) and groups the loads according to their categories (auxiliary machinery loads, hotel loads, propulsion auxiliary and steering loads, etc.). In addition, if indicated by an input option, the program produces a line by line listing of all power consuming equipment and their power category numbers grouped according to their power categories.

The program requires a library of naval ship power consuming equipment.

Language: FORTRAN IV
Machine Requirements: IBM-7090

Source: Naval Ship Engineering Center
(DOD-00010)

Circle 19 on Reader Service Card.

SHIP POWER SYSTEM VOLTAGE DIP CALCULATIONS

This program produces two calculations of voltage dip resulting from motor start-up occurring on a given power generator switchboard. The first calculation is the voltage dip resulting from a motor being started on an unloaded generator. This calculation is done for each motor load on the generator. The second calculation is the voltage dip resulting from multiple motor starts on an unloaded generator. The queuing indicator, combined horsepower and percent voltage dip are shown. Both calculations are repeated for all input generator switchboard data.

Language: FORTRAN IV
Machine Requirements: IBM-7090

Source: Naval Ship Engineering Center
(DOD-00012)

Circle 20 on Reader Service Card.

COMPUTER PROGRAM TO DETERMINE THE PHASE ERROR OF A PHASE-LOCKED LOOP CAUSED BY TAPE RECORDER FLUTTER

Phase-locked loops are frequently used to track the flutter introduced in a data system by a tape recorder. The loop tracks only part of the flutter; i.e., the low frequency flutter components. The high frequency components, not tracked by the loop, create a residual phase error. This computer program simulates a second-order phase-locked loop and determines the phase error between an input subcarrier perturbed by tape recorder flutter and the output of the voltage-controlled oscillator. Static phase error resulting from the velocity drift of the tape recorder and random components of the flutter are not taken into account by the program.

Language: FORTRAN II
Machine Requirements: RCA-601

Source: RCA Corp.
under contract to
Goddard Space Flight Center
(GSC-10584)

Circle 21 on Reader Service Card.

NASA-Langley, 1973

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— NATIONAL AERONAUTICS AND SPACE ACT OF 1958

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